Space Weather Technical Forecast

Issued on Monday, 22 January 2024 at 00:09 Local

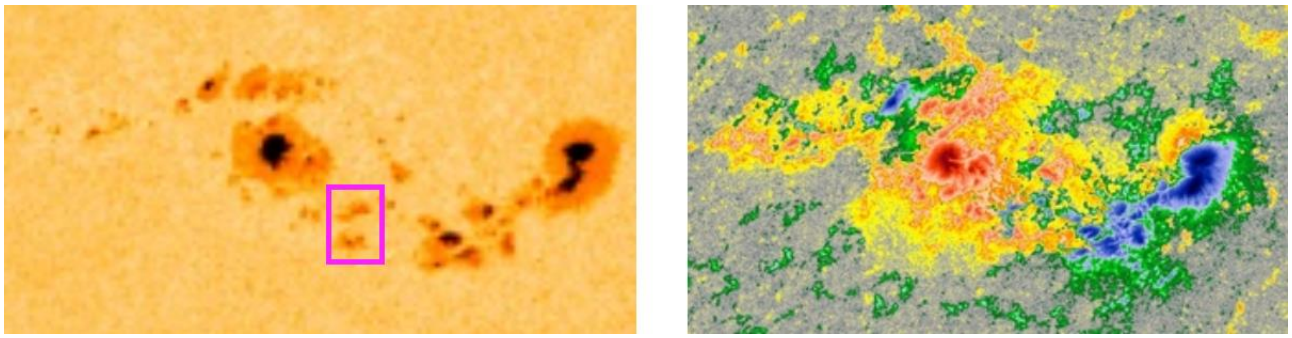
This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Large Earth-directed CME. Moderate Geomagnetic Storm G2 Likely, Chance G3 Monday 22 January. Risk easing into Tuesday 23 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as recorded by GOES16, was Low over the UTC day of Sunday 21 January, with occasional C-class flares observed, largely confined to two episodes that bookended the 24-hour period. These flares peaked with an impulsive C6.7 at 21/1935UTC from the trailing spots of AR3559 in the far northeastern quadrant. This sunspot region has formed at an unusually high solar latitude for this stage of the solar cycle (with a centroid at 27 North), and now spans nearly 20 degrees of solar longitude as an Fac/Beta-Gamma-Delta.

Figure 0: HMIIF and HMIBC imagery from 21/2300UTC, showing AR3559 and its prospective Mt Wilson delta spots boxed magenta.



This sunspot region was one of eight on the visible disc, with a ninth - AR3545 - now no longer visible on the western limb. As stated, by far the largest and most complex group is AR3559 in the northeast, which is showing a congested habit and has numerous candidates for Mt Wilson deltas in its long chains of intermediate spots. This region underwent strong areal growth in its intermediate and trailing portions, with these spots soon migrating outwards from the centre. Also of note in the period were AR3560 and AR3561, which both saw a proliferation of intermediate spots and a spreading tendency.

At 21/0015UTC a filament eruption was seen from the northeast disc, immediately southeast of AR3559, accompanied by a coronal dimming. This feature has been modelled and determined to pass behind the track of the Earth in its orbit to no effect. During the UTC evening, some unusual activity was noted in EUV imagery in the southeastern disc, especially on AIA304 which showed a possible ribbon flare near 40-50 East, which can be a footprint for filament lift-offs, although none was identified. The was accompanied by a slight dimming in AIA 211 and a slight reconfiguration of the geometry of CH94/- in the southeast disc. No subsequent Coronal Mass Ejection (CME) could be identified in available coronagraph imagery, however this is being monitored. Other activity in the period was mainly identified with the off-going western limb and the far side. No new Earth-

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

bound CMEs were therefore in evidence.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR, showed a very slight waning tendency over the UTC day in falling from a Slightly Elevated 400km/s into the high-300s. This appears to be a slow regime between positive polarity coronal holes, with ACE EPAM LEMS now rising - either because of the inbound 20/0840UTC CME, or else because of a CIR leading CH93/+. This is a main aspect of monitoring at present.

The solar wind density was roughly level at Background levels and single-figures ppcc, while the IMF showed a slow fall and rise to a peak of 7nT. The north-south component was variable within limits of +7 and -5nT. The phi angle was mostly positive (away from the Sun), with a brief departure into negative territory around the middle of the UTC day.

The net result of the above solar wind measures was for Quiet geomagnetic activity, with a provisional peak Kp of '2o' seen in the 06-09UTC interval.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 22/0001UTC the 24-hour integrated fluence observation was 1.21e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of isolated M-class flares, with a roughly level trend given an expected lack of significant arrivals and departures.

Solar Wind / Geomagnetic Activity: The overdue fast wind from CH93/+ may now result in a Slight Chance of Active intervals in the first 24 hours prior to the arrival of the CME from the 20/0840UTC southeast-central filament eruption. A most likely arrival time of 22/1800UTC is suggested, with G2 Likely and with a Chance of G3, continuing into the first half of the UTC day of Tuesday 23 January before abating to Quiet conditions by midweek UTC. At the time of writing, a G3 Watch is valid for 22/1200-23/1200UTC.

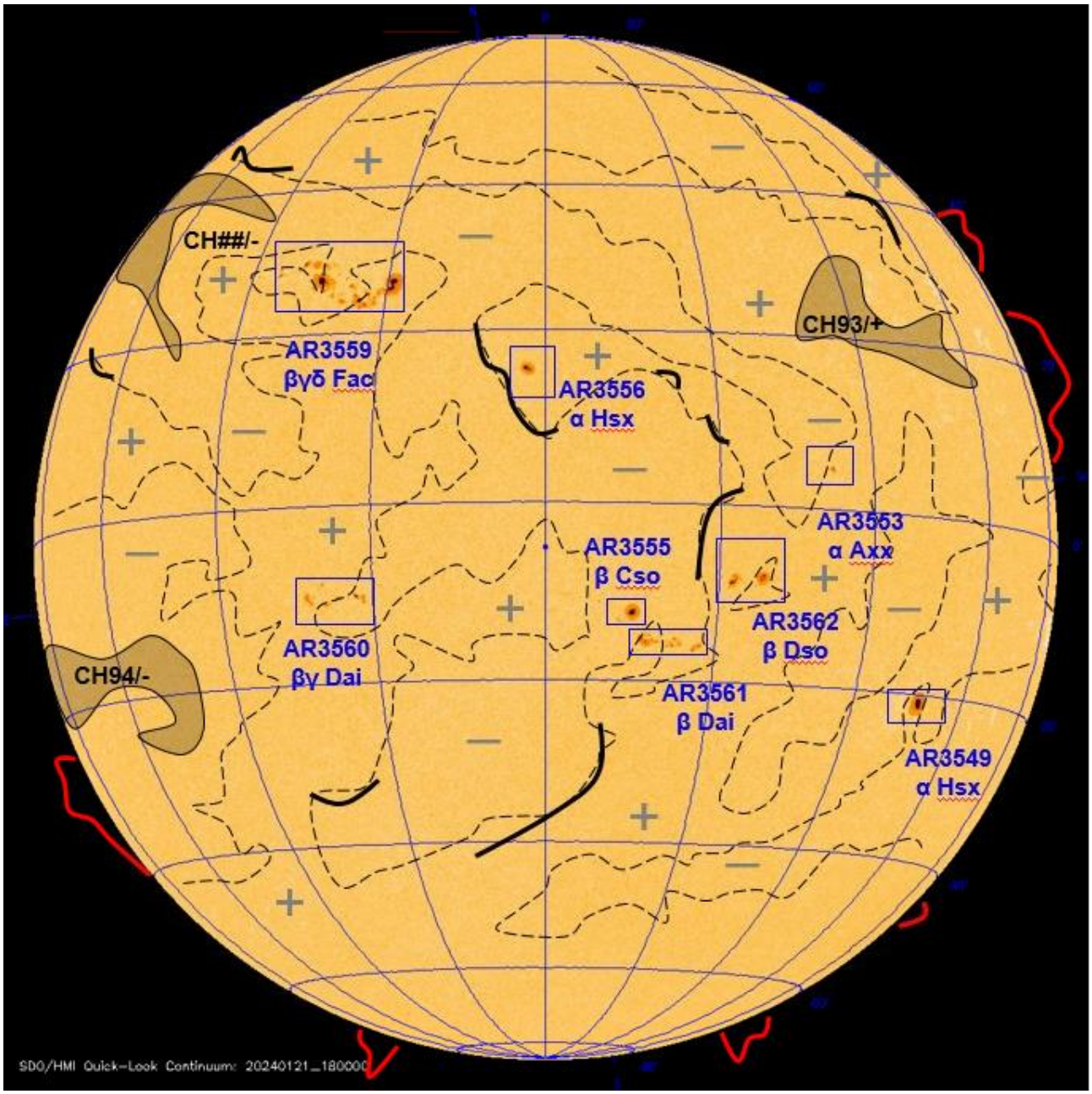
Energetic Particles / Solar Radiation: High energy proton flux is forecast to remain at Background levels.

The high energy electron flux is expected to continue at Normal Background levels initially, with any fast wind from CH93 and an inbound CME significantly increasing uncertainty into the new UTC working week, with a resulting Slight Chance of Active 24-hour integrated fluence as a result on and after midweek UTC.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 1. Solar Analysis Valid 22/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Storms:

The dominant consideration for geomagnetic activity in the new working week is the large helicoidal filament eruption from the southeast-central disc starting 20/0840UTC. Because of a near-concurrent eastern solar horizon prominence eruption, this formed a multi-lobed partial halo CME on coronagraph imagery which complicated analyses. This has been unpicked to a degree and modelled as two separate events, although these are assessed as travelling at similar speeds (around 950km/s), which give a near-continuous shedded 'shell' of ejecta departing the eastern solar hemisphere. While MOSWOC Enlil modelling suggests an arrival time of this CME front at Earth of 22/1500UTC, this has been delayed slightly. The rationale for this is Enlil's ongoing erroneous initialisation with an ongoing 500km/s fast wind - In reality observed speeds are now in the high 300s of km/s. Arrival is therefore suggested at 22/1800UTC, although the magnitude of this adjustment is approximate.

Earth is otherwise currently sampling a sector of space characterised by a positive phi angle and a waning slight enhancement to the solar wind. This may be the tail of CH92/+, however this is uncertain and in any case has not led to significant geomagnetic activity. There may remain one fast wind due imminently - that from CH93/+, however this too is now overdue (if not already in course by stealth). As a result of its late arrival (if still outstanding) expected speeds and resultant geomagnetic activity are now perhaps 400km/s and Active intervals at most. As for an arrival time, the low energy proton spectrum at ACE EPAM LEMS is showing a gradual rise, which could either be a CIR leading this fast wind, or else an early response to the inbound 20/0840UTC CME.

All considered, G2 Moderate Geomagnetic Storm is Likely on Monday 22 January (with G1 or G2 Expected), with an accompanying Chance of Strong Geomagnetic Storm should the Bz fall unfavourably for Earth and the inbound speed be underestimated. At the time of writing, a G3 Watch is in force for 22/1200-23/1200UTC. The risk of G2 should then ebb into the first half of the following UTC day of Tuesday 23 January, with conditions reverting to Quiet around the middle of the coming UTC working week - in the current absence of further drivers of activity.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	50	1	1
Strong	G3	No	30	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/1302	Partial	Filament	SE centre disc	953	22/1800UTC	Main uncertainty arrival time. Delayed from Enlil suggestions of 22/1500UTC due to being injected into erroneous modelled wind.

Figure 2: Latest MOSWOC Enlil and ensemble (badge time 22/1800UTC), showing the 20/0840UTC CME's arrival at 1AU around the middle of the coming UTC afternoon. Note the modelled intervening wind is nearer 500km/s than the observed 375 – this is the rationale for the delay of onset into the earrly evening.

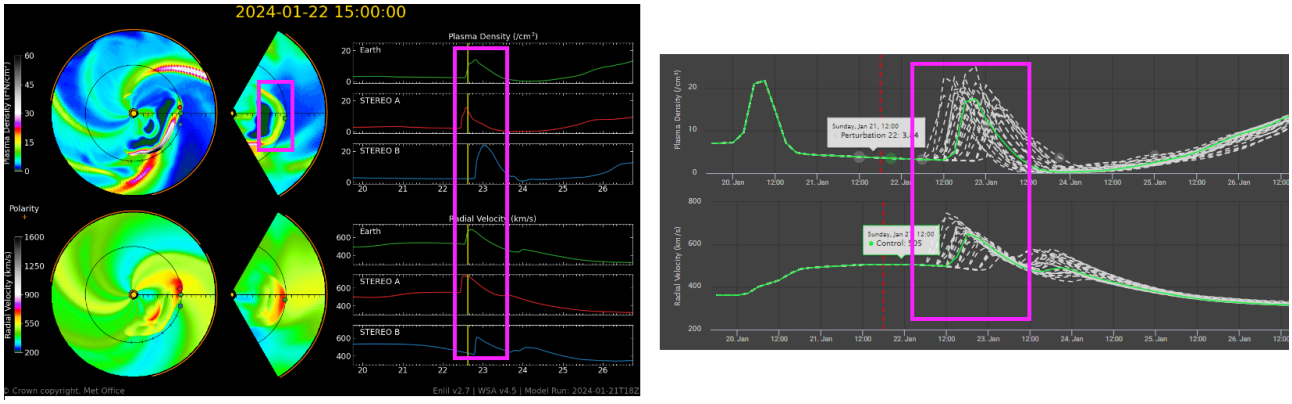
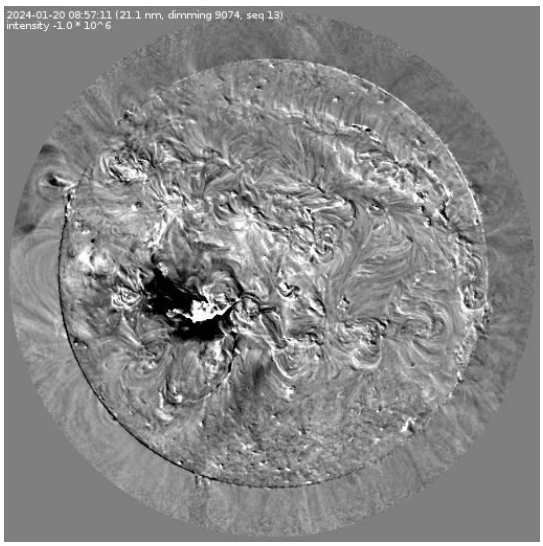


Figure 3: SIDC ROB processed time-integrated AIA 211 dimming of the 20/0840UTC filament eruption.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

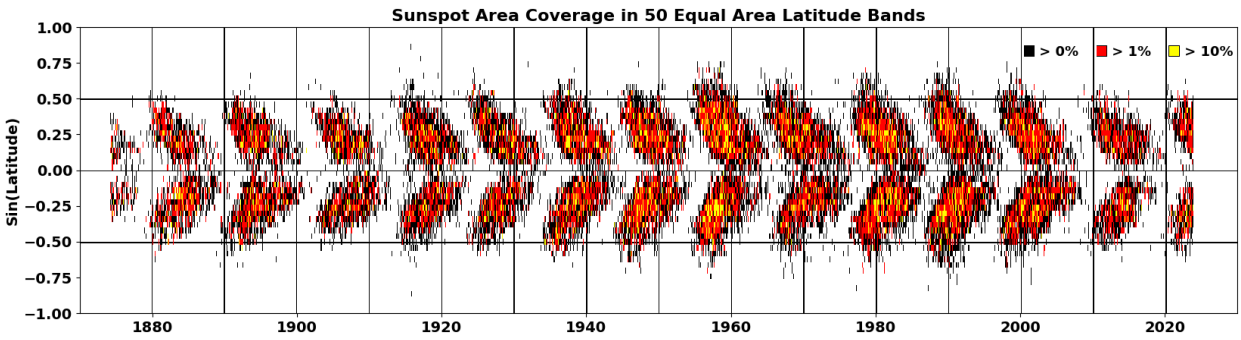
Radio Blackouts - X-Ray Flares:

The recent tendency to have a highly congested Earth-facing disc populated by quiescent sunspot groups appears to be ending, as although there are fewer sunspot groups than entered the past UTC weekend, they are proving more active, even if it has thus far remained within C-class activity. The Penticton 10.7cm flux saw a sharp rise from 166sfu to 179 between the UTC weekend days, possibly mainly tied to the development of AR3559 in the northeast quadrant.

As regards the balance of sunspot groups on the Earth-facing side, the Carrington location for Ex-3534 currently lies on the southeastern limb, and EUV flux loops do hint at some form of survival here, however no significant activity has been noted, and the bulk of the daily risk instead sits with the incumbent regions of the front side, especially AR3559. No significant sunspot regions leave the disc in the four days, and the chances of M-class flares are therefore held at a daily Chance throughout - near the raw risk values for the Zurich classes of the disc's sunspot regions.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 4: Sunspot butterfly diagram, where the y-axis figure of 0.5 corresponds to 30 degrees solar latitude. At 27 North, AR3559 is therefore near the northern extreme of expectations for this part of the cycle. Image courtesy of solarcyclescience.com.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is currently at Background, having shown no response to the long-period C-class flares from the filament and prominence eruptions over the past UTC weekend.

There is a daily Slight Chance of rising and reaching the S1 Minor Radiation Storm threshold in response to any notable flares, with this rising slightly in the period as the CME arrives and the more complex regions of the facing side near more favourably-connecting parts of the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is at Normal Background levels.

The only fast wind that was due in the period is now either overdue or else subtly now in course and not impactful. This was to be the main impetus for departure from the current suppressed state of electrons at GEO, however this now looks less likely. The inbound CME will still render GEO electron behaviour relatively low confidence into the new UTC working week, and there remains a Slight Chance of Active 24-hour integrated fluence.

It remains the case that this is as much a statement of increased 'error bars' as it is any expectation for a rise in populations. MOSWOC REFM is not expected to provide a useful steer given the dominance of a transient in the forecast.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.